AECL EACL

Design Requirement

SPENT FUEL TRANSFER AND STORAGE SYSTEM

ACR-700

10810-35300-DR-001

Revision 0

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1. INTRODUCTION

The purpose of the ACR-700™[1] Spent Fuel (SF) transfer and storage system is to safely transfer irradiated fuel bundles from the fuelling machine (FM) head into the SF storage bay and to store them in the bay until such time that the bundles are transferred to dry storage. The scope of this document is to establish:

a) The overall technical requirements for the ACR-700 SF transfer and storage system, mechanical and controls.

b) The requirements imposed on the SF transfer and storage system by other plant systems, and the requirements imposed on other plant systems by the SF transfer and storage system.

   The requirements imposed on the SF storage bay that have an impact on the handling and safe storage of SF, are considered requirements of the SF transfer and storage system.

c) The requirements identified in this document are for the following subsystems and components:

SF Discharge	35310
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This document excludes any requirements related to the preparation and transportation of dry fuel storage containers.

Some requirements in this document are based on previous experience or on the initial design, and provide guidelines until the final requirements of the ACR-700 are defined.

The SF transfer and storage system design shall also meet the requirements of Reference 1, which lists the general requirements for the Fuel Handling system.

[1] ACR-700™ (Advanced CANDU Reactor-700™) is a trademark of Atomic Energy of Canada Limited (AECL).

1.1 Acronyms

ALARA	As low as reasonably achievable
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing & Materials
ASI	AECL Subject Index
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
DBA	Design Basis Accident
DBE	Design Basis Earthquake
FC	Fuel Channel
FH	Fuel Handling
FM	Fuelling Machine
FCS	Fuel Handling Control System
FDS	Fuel Handling Display System
HT	Heat Transport
IAEA	International Atomic Energy Agency
NF	New Fuel
LOCA	Loss of Coolant Accident
LSFCR	Large Scale Fuel Channel Replacement
LVDT	Linear Variable Differential Transformer
MCR	Main Control Room
MSLB	Main Steam Line Break
RB	Reactor Building
RAB	Reactor Auxiliary Building
SDG	Safety Design Guide
SEU	Slightly Enriched Uranium
SF	Spent Fuel
SFCI	Single Fuel Channel Inspection
SFCR	Single Fuel Channel Replacement

1.2 Definitions

2 bundle shifts	During normal fuel changing operations, two irradiated fuel bundles are removed from the downstream end of a channel, and two NF bundles are inserted into the upstream end of the same channel.
bi-directional channel flow	Flow direction in each channel is opposite to that in adjacent channels.
capacity factor	Ratio of the electrical energy generated to the maximum rated output of the unit over any time interval.
cross flow	The flow of coolant from the reactor inlet feeder pipe perpendicularly across the fuel bundle located in the fuel channel end fitting.
decay	The decrease in activity of a radioactive material as it spontaneously transforms from one nuclide to another, or into a different energy state of the same nuclide.
defective fuel	Fuel bundle with a breach in its cladding that allows radioactive fission products to escape in detectable quantities. Also referred to as defected fuel in other documents.
design basis earthquake (DBE)	This is an engineering representation of the potentially severe effects of earthquakes applicable to the site that have a sufficiently low probability of being exceeded during the lifetime of the plant.
dose	The amount of ionizing radiation energy absorbed per unit of mass of human tissue or organic/elastomeric material.
dual ended fuelling	This is a phrase describing a method of fuel changing where two fuelling machines are used for fuelling. One FM is attached to each end of the fuel channel, and fuelling is with the flow of coolant.
dry storage	A storage system where irradiated fuel is stored in air or inert gas, rather than water. SF is placed in dry storage after its decay heat allows it to be removed from wet storage in the SF storage bay.
forced unavailability	Unavailability caused by work that cannot be postponed beyond the next weekend; generally failures that disable the system and therefore demand immediate repair.
fuel element	A cylindrical, hermetically-sealed, zirconium-alloy sheath containing fuel pellets stacked end-to-end.
fuel string	A series of fuel bundles placed end to end, positioned in a fuel channel.
maintenance unavailability	Planned downtime that had to be organized before the next scheduled fuel handling outage.

planned unavailability	Unavailability caused by work that can be postponed to the next scheduled fuel handling outage.
safeguards	IAEA safeguards for radioactive and fissile material. A system of technical measures to monitor the location of fissile materials within the framework of the international Non-Proliferation policy entrusted to the IAEA in its statute and by the Non-Proliferation Treaty
shield plug	The channel hardware that positions the fuel string within the fuel channel. It incorporates features that help straighten the coolant flow and provides shielding for maintenance staff during shutdown conditions.
spent fuel	Nuclear fuel that has been irradiated in a reactor. It is also termed “irradiated fuel” or “used fuel”.

2. FUNCTIONAL REQUIREMENTS

The overall functional requirements of the SF transfer and storage system are as follows:

a) The SF transfer and storage system shall safely transfer irradiated bundles from the FM head into the SF storage bay and store them in the bay until such time that the bundles are transferred to dry storage.

b) The availability of the Fuel Handling portion of the containment system shall be maintained.

c) Safe fuel temperatures shall be maintained during fuel transfer and storage.

To satisfy these overall requirements, the following safety, operational, instrumentation and control, and abnormal functional requirements shall be satisfied.

2.1 Safety Functional Requirements

The SF transfer and storage system must satisfy the following safety related functional requirements:

a) Irradiated fuel shall remain cooled and submerged throughout the SF transfer process.

b) The SF transfer process system, a subsystem of the SF transfer and storage system, shall dissipate the heat generated by up to six pairs of SF bundles in the SF transfer magazine, or five pairs in the transfer magazine and one pair in the SF transfer tube, with the SF port valves closed, to prevent fuel failures or bundle distortion that would prevent fuel transfer.

c) A break in the SF transfer port, SF transfer tube, SF transfer process piping or a control failure shall not lead to draining of the SF bays. A failure of the normal water supply, or a control system failure shall not drain the SF transfer tube or SF transfer process system.

d) The design of SF bays shall not include drains, permanently connected systems and other features that, by mis-operation or failure could cause sufficient loss of SF bays water to uncover fuel.

e) The system shall facilitate fuel cooling by an emergency cooling water system, during and following a DBE and whenever the normal water supply from the SF transfer process system is otherwise not available due to a system failure or malfunction.

f) The SF transfer system shall not impair availability of the FH portion of the containment system.

g) The SF transfer tube and SF transfer process system, from the containment wall to the isolation valves on the RAB side, shall be maintained at a pressure above the Reactor Building (RB) design pressure at all times, to provide a backup to the containment function of the SF port containment valves, and to facilitate leak detection from the SF transfer process system.

h) The SF port valves (containment isolation valves) shall be prevented from opening if the FM is not clamped to the SF port, or if the pressure on the RAB side of the valves is below that of containment.

i) The SF port valves (containment isolation valves), and process valves on the SF transfer tube and SF transfer process system, which are required for containment isolation, shall be provided with the ability to be stroked at least once (closed) during and following a LOCA, MSLB or DBE.

j) All valves required for containment isolation shall have valve position sensing and shall be monitored from the FH control console in the Main Control Room (MCR).
k) The SF transfer system shall maintain a safe state and not lose position data after an interruption of power.
l) The SF transfer and storage system shall not damage fuel.
m) Valves that provide a passage for irradiated fuel bundles and other hardware shall be prevented from closing on the fuel or hardware.
n) The SF transfer system shall act as a barrier to the release of radionuclides to the environment from defective fuel bundles, and shall be capable of storing defective fuel bundles such that fission product gasses are released and safely discharged to the Off Gas Management system. This is required to limit radiological emissions to ALARA.
o) Manual tools and equipment shall be provided in the reception bays for the handling and canning of defective fuel bundles.
p) Access controls and interlocks shall be used to prevent radiation exposure in areas of potential hazard, such as the FM maintenance lock and the area around the SF transfer tube.
q) Mechanisms such as hoists in the SF storage bay that have the ability to elevate the SF storage containers must have an interlock to prevent lifting the storage containers above the minimum depth of water for radiological protection. A means of bypassing this interlock shall be provided to permit the handling of empty SF storage containers.

2.2 Operating Functional Requirements

2.2.1 Mechanical and Process

a) The SF transfer system shall incorporate a SF port, SF transfer tube and SF transfer mechanism to service each FM, for a total of two of each per ACR-700 unit (Reference 1). There shall be a common SF transfer process system to create hydraulic drag for fuel transfer through either SF transfer tube, and to provide cooling for the fuel while it is in the SF transfer system. SF bay(s) shall be provided for the storage of SF from both the FMs.
b) The SF transfer and storage system shall be able to receive SF bundles, a fuel grappling assembly with an attached irradiated fuel bundle, a fuel grapple extension, or a shield plug, from the FM heads and transfer them through containment to the SF reception bays, which are physically separate from the main fuel storage bay, to which SF and hardware are first transferred from the FM.
c) Facilities shall be provided in the SF reception bays to transfer the SF to SF storage containers.
d) The handling of SF in the SF storage bay shall be minimized to maintain operational doses to ALARA.
e) The SF storage containers shall hold a single layer of bundles vertically.
f) Irradiated fuel bundles shall be transferred in pairs, from the FMs to the SF reception bays. However, SF bundles shall be loaded into the SF storage containers singly.

g) The SF transfer and storage system shall have the capability to transfer all 12-fuel bundles of a maximum power fuel channel, from the SF port to the SF storage bay, during a single visit of the FM to the SF port, to facilitate single channel replacement, periodic channel inspection, and the replacement of defective fuel.

h) The SF transfer system shall be capable of transferring defective fuel bundles.

i) The design of the SF transfer and storage system shall minimise the risk of irradiated fuel or hardware becoming stranded in the system.

j) A manbridge shall be provided in the SF storage bay for the handling of SF storage containers, IAEA sealing and inspection equipment, for the operations and maintenance of the SF storage bay equipment, and to manipulate all manual underwater tools. The manbridge shall incorporate a motorized hoist for lifting and traversing SF storage containers and other equipment submerged.

k) The SF storage bay equipments shall handle full, empty, and partly full storage containers.

l) Manual tools shall be provided for the handling of shield plugs, and intact or defective SF bundles or fuel elements in the SF storage system.

m) The SF port assembly shall have a replaceable end fitting similar to the coolant channel end fitting, for the FM to clamp onto and make a pressure/leak tight seal.

n) The SF port assembly shall be capable of handling any loads transferred to it from the FM that result from FM misalignment during homing, FM imbalances, and seismic events.

o) The stroke of the FM ram shall be considered when locating the SF port containment valves.

p) The SF transfer system shall facilitate the installation and maintenance of IAEA safeguards equipment, such as fuel bundle counting and detection equipment, and remote viewing equipment.

q) The SF transfer process system, a sub-system of the SF transfer and storage system, shall be able to move a pair of fuel bundles, a fuel grappling assembly with an attached irradiated fuel bundle, a fuel grapple extension, or a shield plug, from the SF ports to the SF reception bays.

r) The transfer of water from the FMs to the SF storage bay via the SF transfer process system shall be minimized to limit the amount of potential tritium and contamination in the SF storage bay.

s) Under normal operating conditions, direct transfer of water from the SF reception bay to the heat transport (HT) system via the FM shall be avoided. Any transfer of mixtures containing bay water shall be minimized.

t) The water in the SF transfer system shall be demineralised water to minimize the transfer of water from the FM to the SF storage bay, and to keep the internals of the SF Transfer system free of crud and other contaminants.

u) All valves required for containment isolation shall be remotely operated, but have local manual override capability.

v) SF bundles that have been freshly discharged from the reactor core and therefore have a high initial decay heat load, shall be stored in SF storage containers in buffer zones in the SF reception bays, in a manner that ensures sufficient heat dissipation. They shall remain in the buffer zones until they have cooled sufficiently to be transferred to the stacking frames in the main SF storage bay.

w) The design of the SF storage containers and stacking frames shall facilitate SF cooling and shall optimize the use of the fuel storage space in the SF bays.

x) Sufficient clearance shall be maintained from the SF bay floors and walls to the SF storage containers to avoid over heating of the SF bay floors or walls.

y) The SF transfer system shall have a provision in the SF reception bays, for remote visual inspection of SF bundles.

z) The SF transfer system shall have a provision in the SF reception bays for the verification of the serial numbers that are stamped on the endplates of SF bundles. SF storage containers shall be stored in the SF storage bay with satisfactory identification.

aa) The SF transfer system shall have a provision in the SF reception bays, for the remote visual inspection of defective fuel.

bb) The design of the SF storage containers and stacking frames shall facilitate the transfer of SF to dry storage after a period of interim storage in the SF storage Bay.

cc) The design of the SF storage containers shall take into consideration the existing AECL shielded workstations used to prepare SF for dry storage, the existing flask being used for transfer of the SF to the dry storage facility, and any modifications required to them to accommodate ACR-700 fuel.

dd) The SF storage containers shall be suitable for temporary (on-site) and permanent (off-site) dry fuel storage.

ee) The use of the SF storage containers for the shipping and storage of NF bundles shall be considered. Storage containers that have been in the SF bays and/or used for SF storage shall not be used for NF storage.

ff) Facilities shall be provided to accommodate dry fuel storage or other methods of fuel removal from the SF storage bay. These facilities, some of which may be installed at a later date shall include:

- Space for impact pads (crash pads).
- A heavy lift crane for flask handling. The crane shall incorporate restrictions on the lifting height to limit impact loads on the SF storage bay structure and associated safety related equipment, and restrictions on the operating/travel envelope over the SF storage bay to minimise any risk to stored fuel.
- Flask washdown and decontamination facilities to minimise external radiation fields and the spread of contamination.
- Other features to ensure that fuel transfer out of the SF storage bay cannot jeopardize the integrity or cause releases from the fuel stored in the SF storage bay.

2.2.2 Instrumentation and Control

a) The SF transfer system controls shall be designed for the transfer of SF and hardware from the FMs to the SF storage bay, and shall also be designed to accommodate the transfer of SF back to the FMs, and hardware from the SF reception bays to the FMs.

b) SF and hardware transfers (i) from the FM into the SF transfer magazine, and (ii) from the SF transfer magazine into the FM shall normally be initiated by the FH operator in the MCR, and executed in auto-step mode. All other modes of operation that are supported by the FH control system shall be possible (Reference 2).

In addition, limited backup controls independent of any programmable device shall be provided to maintain normal or emergency cooling, and to maintain or re-establish containment or otherwise maintain the SF transfer system in a safe state in the event of a FDS/FCS failure.

c) SF and hardware transfers (i) from the SF transfer magazines into the SF reception bays, (ii) from the SF reception bays into the storage containers, and (iii) from the storage containers onto the SF reception bays, and (iv) hardware transfers from the SF reception bays into the SF transfer magazines shall normally be initiated and executed in single-step mode by a FH operator in the SF bay room, with minimal manual intervention. All other modes of operation that are supported by the FH control system shall be possible, except for auto-step mode (Reference 2).

   An emergency stop button shall be provided near to the SF transfer equipment, so that a field operator can stop operations if there are problems.

d) A means shall be provided to confirm that a pair of fuel bundles, a single fuel bundle, or a piece of hardware has reached the SF transfer magazine from the FM. Similarly, a means shall be provided to confirm that a pair of fuel bundles, a single fuel bundle, or a piece of hardware has reached the FM from the SF transfer magazine.

e) In addition to the normal SF transfer system controls, the following shall be provided:
   1) Controls that are independent of any programmable device, shall be provided on the FH backup panel to:
      i) monitor the temperature of the water in the SF transfer system.
      ii) generate alarms when the temperature exceeds a pre-defined value, which is identified in Appendix A, so that corrective action can be taken.
      iii) control manually the emergency SF transfer cooling system, to initiate flow and control direction of flow to the appropriate location.
   2) Automatic control of the emergency SF cooling system, to initiate flow and control direction of flow to the appropriate location when the temperature reaches an unacceptable value. A suitable value is identified in Appendix A.
   3) Controls that are independent of any programmable device, shall be provided on the FH backup panel to:
      i) monitor the status of the containment isolation valves and the pressure in the SF transfer tube.
      ii) generate an alarm when the pressure drops below a pre-defined value, which is identified in Appendix A and indicates that containment may be compromised under certain conditions.
      iii) control manually the containment isolation valves.

f) The SF transfer mechanism equipment drives shall generally use variable speed electric servomotors with position sensing by absolute resolvers. All moving equipment shall have redundant position sensing where practical. All drives shall have provisions for manual cranking. Wherever practical, the drive motors and position sensors shall not be submerged.

g) Wherever practical, discrete motion actuators such as solenoids, and discrete position sensors, such as limit switches shall not be submerged.

h) Local controls only shall be provided for operation of the SF storage bay manbridge and associated hoist. The main controls shall be located on the manbridge. Secondary manual controls may be provided elsewhere in the SF bay room.

i) The controls on the manbridge shall be enclosed in a heavy duty, moisture-proof enclosure.

j) Mechanical equipment that does not have mechanical overtravel stops shall have electrical interlocks to prevent overtravel and shall have appropriate indication.

k) Driven equipment that can be damaged or can damage other equipment if it travels beyond its normal operating envelope, shall be provided with overtravel indication and interlocks to inhibit further motion in the direction of overtravel.

l) Mechanisms, which normally drive to stall shall be provided with end of travel indication.

2.3 Abnormal Functional Requirements

a) The SF transfer and storage system shall be able to transfer the entire fuel bundle complement of the reactor core in pairs from the SF ports to the SF reception bays and then, in SF storage containers to the main SF storage bay, for large scale channel replacement or plant decommissioning.

b) The SF transfer process system shall be able to move a pair of fuel bundles, a fuel grappling assembly with an attached irradiated fuel bundle, a fuel grapple extension, or a shield plug, from the SF transfer magazine to the FM.

c) The SF transfer and storage system shall allow for transfer of a single fuel bundle.

d) Manual tools shall be provided for handling a fuel grapple extension, and a fuel grapple tool assembly with an attached irradiated fuel bundle, in the SF bays.

e) The design shall provide a means of retrieving SF bundles that cannot complete the transfer between the FM and the SF transfer magazine under hydraulic drag. The design shall facilitate the insertion of inspection equipment and fuel bundle retrieval tools into the SF transfer tube.

3. PERFORMANCE REQUIREMENTS

3.1 Normal Operation

a) The SF storage bay shall have sufficient storage capacity (i) to accommodate the SF bundles until they are sufficiently cooled for transfer to dry storage, (ii) to provide for some delay prior to transfer to dry storage, and (iii) to address any contingency requiring core dumping. A suitable storage capacity and storage period are specified in Appendix A.

b) The SF reception bays shall each have a buffer zone, for storing SF storage containers until the SF has cooled enough to allow them to be transferred to storage frames. A minimum storage period in the buffer and a suitable storage capacity for the buffer zone are specified in Appendix A.

c) The SF transfer mechanisms shall have the capacity specified in Appendix A.

d) The normal refuelling rate and duty of the SF transfer and storage system shall be as specified in Appendix A.

e) The SF transfer and storage system shall accommodate an accelerated SF transfer rate, to facilitate building up excess reactivity in the core prior to a FH outage (advance fuelling), or to restoring reactivity in the core following a FH outage (catch-up fuelling). The advance or catch-up SF transfer rate and duty of the SF transfer and storage system shall be as specified in Appendix A.

f) The SF transfer and storage system shall facilitate pressure tube inspections as follows:

   Near the start of a unit outage, the SF transfer system shall be able to transfer the irradiated fuel complement of a limited number of channels to the SF storage bay in a timely manner.

   The number of channels and time period are specified in Appendix A.

g) The SF transfer and storage system shall accommodate defective fuel at a rate specified in Appendix A.

h) The SF transfer process system shall have a sufficient flow to move a pair of fuel bundles, a fuel grappling tool assembly with an attached irradiated fuel bundle, a fuel grapple extension, or a shield plug between the SF port and the SF transfer magazine, and provide adequate cooling for up to six pairs of SF that have been removed from a maximum power channel. A suitable minimum flow, and the exit burn up of SF from a maximum power channel are identified in Appendix A.

i) The maximum permissible leakage through the valves, which are maintaining the containment, (e.g. SF port valves) shall be as specified in Appendix A.

3.2 Abnormal Operation

a) The SF transfer and storage system shall facilitate complete core de-fuelling in the time period specified in Appendix A.

b) The SF transfer and storage system shall accommodate the maximum number of FM trips to the SF port identified in Appendix A.

3.3 Safety Related

a) SF stored in the SF storage bay shall be cooled by natural convection. The maximum safe fuel temperature is documented in Appendix A.

b) The SF transfer and storage system shall incorporate sufficient biological shielding over all its components and over SF, to limit radiation fields to acceptable levels as specified in the safety requirement Section A.4 of Appendix A. The minimum water shielding over the SF storage containers shall be as specified in Appendix A.

4. SAFETY REQUIREMENTS

4.1 Applicable Requirements from Safety Design Guides

The designer shall ensure that the requirements defined in the ACR-700 Safety Design Guides are met and that the requirements are updated if the Safety Design Guides are revised.

The Safety Design Guides for the SF transfer and storage system are identified under the following Reference sections:

Safety Related Systems, Seismic Requirements, Environmental Qualification Requirements, Fire Protection Requirements, Containment Requirements, Radiation Protection Requirements, and Separation of Systems and Components Requirements.

4.1.1 Safety Related Systems (Reference 3)

a) The SF transfer and storage system shall cool the SF during transfer and storage during normal operation. This requirement applies to SF in the SF transfer tube (when SF port valves are closed) or in the SF transfer magazine.

b) Under normal operating condition, the SF shall be submerged at all times. Under abnormal operating condition the SF may be removed from the water for a maximum period identified in Appendix A.

c) The SF transfer and storage system shall limit the release of radioactive material to the environment.

d) During design basis events such as earthquakes, the SF transfer system shall not cause any fuel damage that results in the regulatory dose limits to be exceeded.

e) Special design features are required to ensure against criticality during SF transfer and SF storage in the SF storage bay.

f) Correct operation of the SF transfer and storage system (containment and emergency cooling valves) after an accident shall not depend on Class IV power.

g) If operator action is required for actuation of any safety equipment (containment, and operation of emergency cooling valves), the following requirements shall be met:

   1) Instrumentation (with built in redundancy) shall give the operator clear and unambiguous indication of the necessity for operator action.

   2) The reliability of such instrumentation shall commensurate with the requirements of the availability of the safety system.

   3) There shall be at least 15 minutes after clear and unambiguous indication before operator action in the MCR is required.

   4) There shall be clear, well-defined and readily available operating procedures to identify the necessary actions.

4.1.2 Seismic Requirements (Reference 4)

a) Passive containment boundary components (that is the SF port with seal plate on containment wall, the SF transfer tube, and connected SF transfer process piping up to the isolation valves) shall be qualified to DBE category 'A', to maintain the containment boundary and to facilitate fuel cooling.

b) Equipment shall be qualified to DBE category 'B', if required to establish a containment boundary (e.g. SF port valves), provide emergency fuel cooling, or avoid fuel damage by inadvertent closing of valves through which fuel may be passing.

c) Structures, subsystems and components whose failure would result in the release limits being exceeded (e.g. the stacking frames in the SF storage bay) shall be seismically qualified.

d) The SF transfer system components whose failure could cause drainage of the SF storage bay shall be seismically qualified for DBE.

e) Structures and components whose failure may pose a hazard to seismically qualified systems shall also be qualified sufficiently that the safety function of the seismically qualified systems is not affected, or the seismically qualified systems shall be suitably protected.

f) Equipments shall be seismically qualified and documented in accordance with Reference 4.

4.1.3 Environmental Qualification (Reference 5)

a) Containment boundary components inside the RB (that is, the SF port with SF port valves, and the SF transfer tube up to and including the seal plate on the containment wall) shall be environmentally qualified per Reference 5, to maintain the containment integrity during and following a LOCA or MSLB.

b) Components that are subjected to the harsh environment of a LOCA or MSLB, and are required to be functional to provide or facilitate emergency fuel cooling shall require environmental qualification as per Reference 5.

c) Containment boundary components outside the RB that are subjected to the harsh environment created by a pressure boundary failure of the steam generator feedwater system shall be protected from, or qualified for that environment.

d) Components outside containment that are subjected to the harsh environment created by a pressure boundary failure of the steam generator feedwater system, and are required to be functional to provide or facilitate emergency fuel cooling shall be protected from, or qualified for that environment.

4.1.4 Fire Protection (Reference 7)

a) The containment boundary shall be maintained during and following fires that could cause a release of fission products within containment.

b) SF cooling (refer to Section 2.1-b)) shall be maintained during and following fires.

c) The use of combustible materials and the leakage of lubricating oil shall be minimized. Wherever lubricating oil or hydraulic fluid is used, measures shall be taken to prevent the spread of oil/fluid in case of component failures.

d) Power and control cables used in the SF transfer and storage system shall meet the flame spread rating and shall not exceed the allowable corrosive gas releases specified in Reference 7.

e) Ignition due to electrical equipments or sparking materials shall be considered in the design.

4.1.5 Containment (Reference 8)

a) Sections of the SF transfer and storage system that form part of the containment boundary shall be designed in accordance with CNSC Regulatory Policy Statement R-7 and CAN/CSA-N285.0. Containment Safety Design Guide, 108-03650-SDG-006 shall be used to interpret CNSC Regulatory Policy Statement R-7.

b) Containment extensions and code classification shall be clearly identified on system flowsheets, and identified and listed in the Design Descriptions.

4.1.6 Radiation Protection (Reference 9)

a) The sources of radiation and radioactive material shall be reviewed to identify potential hazards. The radiation dose limits are identified in Appendix A.

   Access controls shall limit access to the areas with high radiation, to meet the requirements in accordance with Reference 9.

b) The SF port assembly and SF port valves, and the SF transfer tube and associated components shall be provided with Radiation Shielding to meet the requirements in accordance with Reference 9.

c) Sufficient water shielding over the SF storage containers shall be maintained in the bay to meet the requirements in accordance with Reference 9.

d) Interlocks shall prevent opening of the SF port valves (containment isolation valves) except during SF transfer operations.

e) Tritium concentration resulting from SF transfer must be controlled by confinement, containment and process control.

f) Radiation monitors shall be provided around work and equipment areas to detect radiological hazards to personnel and to detect/confirm the presence of defective fuel.

4.1.7 Separation of Systems and Components (Reference 6)

The SF transfer and storage system and components shall meet the physical and functional separation requirements specified in Reference 6.

4.2 Specific Requirements from Applicable CNSC Regulatory Documents

The specific requirements from applicable CNSC regulatory documents are addressed in other sections of this document (Refer to Sections 2.1, 4.1.5, 5.3.1, 8.1, and 15.2).

4.3 Protection Against Environmental Hazards

a) Refer to Sections 4.1.2 and 4.1.3 for the seismic and environmental qualification requirements.

b) The SF transfer and storage system shall be designed so that any power failure results in all equipment being in a safe state.

4.4 Protection Against Impact Forces

a) The SF storage bay, SF transfer tube and SF port with port valves (containment valves) shall not be located where they could be damaged by turbine blade missiles.
b) High energy system piping shall not be located in the vicinity of the SF storage bay, SF transfer tube, SF port with port valves (containment valves) and any other equipment that is required to maintain or establish containment, or to provide or facilitate emergency fuel cooling, to avoid impact forces generated by pipe whip. Alternatively, this equipment/component shall be protected from pipe whip or measures shall be taken to eliminate the impact forces.

4.5 Fire Protection

Refer to Section 4.1.4 for the fire protection requirements.

4.6 Industrial Safety Requirements

a) The design of the SF transfer and storage system shall meet the requirements of applicable Canadian National Codes and Standards pertaining to electrical safety, material handling and general industrial safety.
b) Protection from accidental over-travel shall be provided with mechanical means or electrical interlocking for equipment.
c) Non-nuclear component and supports, with the exception of components and supports that must be seismically qualified to protect safety related systems, shall be designed to the requirements of the National Building Code of Canada. Their seismic design shall be in accordance with an earthquake level associated with Zone 2 of the National Building Code of Canada.

4.7 Operational Safety Requirements

a) In situations where asynchronous or inadvertent operation of the equipment will compromise nuclear safety or have a significant economic impact, hardware interlocks shall be provided to minimize the risk. Software shall not be credited in any portion of the interlock. The “interlock” can be an electrical circuit or a piece of mechanical hardware.
b) Equipment shall be designed to be failsafe.
c) Sufficient manual control of individual drives shall be provided to bring the SF transfer and storage system to a safe state.

5. APPLICABLE CODES, STANDARDS, CODE CLASSIFICATION AND QUALITY ASSURANCE LEVEL

The design of the SF transfer and storage system shall comply with the applicable regulatory codes and standards.

5.1 Codes and Standards

The following codes and standards are applicable to the design of the SF transfer and storage system:

Codes or Standards	Title
CSA N285.0	General Requirements for Pressure-Retaining systems and Components in CANDU Nuclear Power Plants
CSA N285.3	Requirements for Containment Systems Components in CANDU Nuclear Power Plants
CSA N285.4	Periodic Inspection of CANDU Nuclear Power Plant Components
CSA N285.5	Periodic Inspection of CANDU Nuclear Power Plant Containment Components
CSA N286	Quality Assurance Program Requirements for Nuclear Plants
CSA N286.1	Procurement Quality Assurance for Nuclear Power Plants
CSA N286.2	Design Quality Assurance for Nuclear Power Plants
CSA N286.3	Construction and Installation Quality Assurance for Nuclear Power Plants
CSA N286.4	Commissioning Quality Assurance for Nuclear Power Plants
CSA N286.5	Operation Quality Assurance for Nuclear Power Plants
CSA N289.1	General Requirements for Seismic Qualification of CANDU Nuclear Power Plants
CSA N289.2	Ground Motion Determination for Seismic Qualification of CANDU Nuclear Power Plants
CSA N289.3	Design Procedures for Seismic Qualification for CANDU Nuclear Power Plants
CSA N289.4	Testing for Seismic Qualification of CANDU Nuclear Power Plants
CSA N289.5	Instrumentation Inspection and Records for Seismic Qualification of CANDU Nuclear Power Plants
CSA N290.5	Requirements for the Support Power Systems of CANDU Nuclear Power Plants
CSA N290.6	Requirements for Monitoring the Display of CANDU Nuclear Power Plant Status in the Event of an Accident
CSA N290.13	Requirements for Environmental Qualification of Equipment for CANDU Nuclear Power Plants
CSA N293	Fire Protection for CANDU Nuclear Power Plants
ISO 9001-2000[2]	Quality Management Systems - Requirements
CNSC, G-219	Decommissioning Planning for Licensed Activities
CNSC, R-7	Requirements for Containment Systems for CANDU Nuclear Power Plants
CNSC, R-90	Policy on the Decommissioning of Nuclear Facilities
CNSC, P-119	Policy on Human Factors

2 Any exclusions permitted under clause 1.2 of this standard, shall be limited to those specifically noted in the Tender Documents. Any other exclusion shall be identified, justified and accepted by the customer. The supplier shall also comply with the other Quality Assurance requirements specified in the Tender Documents.

5.2 Safety Design Guides

108-03650-SDG-001 AECL Safety Design Guide – Safety Related Systems

108-03650-SDG-002 AECL Safety Design Guide – Seismic Requirements

108-03650-SDG-003 AECL Safety Design Guide – Environmental Qualification

108-03650-SDG-004 AECL Safety Design Guide – Separation of Systems and Components

108-03650-SDG-005 AECL Safety Design Guide – Fire Protection

108-03650-SDG-006 AECL Safety Design Guide – Containment

108-03650-SDG-007 AECL Safety Design Guide – Radiation Protection

5.3 System/Component Classification

5.3.1 Containment Boundary Components and Supports

a) Containment boundary components and supports (for example, the SF Port assembly including the SF port valves, and a portion of the SF transfer tube) shall be classified as CAN/CSA-N285.0 Class 2. They shall also meet the requirements of CNSC Regulatory Document R-7.

b) The seal plate on the RB containment wall, between the containment structure embedment and the SF port assembly/SF transfer tube shall be classified as Class 4 and shall meet the requirements of CAN/CSA-N285.3.

c) Periodic Inspection of Containment Components and their supports shall be performed as per CAN/CSA-N285.5. Periodic Inspection shall also comply with the requirements of CNSC Regulatory Document R-7.

5.3.2 Other Pressure Retaining Components and Supports

a) Other pressure retaining components and supports of the SF transfer and storage system (for example, the transfer ram housing, loading ram housing, SF magazine housing, and a portion of the SF transfer process system) shall be classified as Class 6 and shall meet the requirements of CSA B51, unless tritium or activity concentrations demand Class 3 per CAN/CSA N285.0.

b) Periodic Inspection of components and supports shall be performed as per CAN/CSA-N285.4.

5.3.3 Non-pressure Retaining Components and Supports

a) Non-pressure retaining components and their supports shall meet the requirements of the National Building Code of Canada.

b) Stacking frames for the SF storage containers shall be seismically qualified to DBE category ‘A’.

5.3.4 Fissionable Materials Safeguards

a) The design of the SF transfer and storage system shall be suitable for incorporation of IAEA Safeguards (Reference 15).

b) The SF storage bay shall conform to the IAEA definition of dual containment and surveillance: two redundant containment or surveillance methods based on physically independent and diverse principles used to safeguard the same material (e.g. Closed circuit television surveillance in combination with the application of ARC seals).
c) The SF in the SF storage bays shall be stored in containers and stacking frames with tamper-indicating covers.
d) The containers and stacking frame size shall facilitate sealing every SF bundle in a full stacking frame within a time frame that will satisfy the IAEA safeguards requirements. For a suitable time frame refer to Appendix A.

5.4 Quality Assurance/Quality Control

a) The Quality Assurance level for the procurement, design, fabrication and installation of components classified as nuclear Class 2 or Class 3, and their supports, shall be as per CSA N285.0.
b) The Quality Control for the pressure retaining components classified as Class 6, and their supports, shall be as per CSA B51.
c) The Quality Control for the components classified as Class 4 shall be as per CAN/CSA-N285.3.
d) The Quality Control for the non pressure retaining portion of the SF transfer and storage system shall be as specified in the design specification of the individual components.
e) The Quality Assurance Program shall be as per Reference 10.

5.5 Registration Requirements

The design of the pressure retaining portion of the SF transfer and storage system and its supports shall be prepared for registration with the regulatory authority in accordance with the requirements of CAN/CSA–N285.0 and CSA B.51, as applicable.

6. ENVIRONMENTAL CONDITIONS

The environmental conditions for the SF transfer and storage system are defined by the conditions in (i) the FM maintenance lock in the RB, (ii) the area in the RAB between the RB and the SF reception bays, and (iii) the SF bay room. The conditions existing at these locations are identified in Appendix A.

7. OVERPRESSURE PROTECTION

a) Overpressure protection of Class 2, 3 and 6 portions of the systems shall meet the requirements of CAN/CSA-N285.0.

b) Overpressure protection of Class 4 components shall meet the requirements of CAN/CSA-N285.3.

c) An overpressure protection report shall be prepared in accordance with CAN/CSA-N285.0.

d) Overpressure protection discharge must not breach containment and must not spread contamination.

e) For over pressure protection of pressure retaining components of the SF transfer system, two relief valves shall be provided.

   One Relief valve shall be provided to protect the system from over pressurization in case of a FM system controls failure, when the FM is on the SF port, prior to opening of SF port valves (containment valves).

   The second relief valve shall be provided to protect the SF transfer tube, the SF transfer magazine housing and the SF transfer process system against over pressurization by the SF transfer process system, when the SF port valves (containment valves) are closed. It shall be located on the SF transfer process piping.

8. INSPECTION AND TESTING

8.1 Periodic Inspections

a) It shall be shown by analysis that the pressure-retaining portion of the SF transfer and storage system meets the requirement for inspection category C2 of CAN/CSA-N285.4. Otherwise, the SF transfer and storage system shall be designed to facilitate periodic inspection of the pressure retaining components and their supports in accordance with the requirements of CAN/CSA-N285.4.

b) The SF transfer and storage system shall be designed to facilitate Periodic Inspection of containment components and their supports in accordance with the requirements of CAN/CSA-N285.5. Periodic Inspection shall also comply with the requirements of CNSC Regulatory Document R-7.

c) The SF transfer and storage system design shall permit inspection using the methods and intervals specified in the relevant standards and codes.

d) The control and instrumentation of the SF transfer and storage system shall be tested/calibrated periodically to ensure the adequacy and availability of all controls and monitoring components. Where practical, instrumentation testing shall be part of the process system.

8.2 Testing

a) Pressure boundary and containment boundary components shall be pressure tested on installation, as defined in the standards or codes to which they are designed.

b) Provision shall be made for routine leakage testing of the containment boundary. The test method and acceptance criteria shall be specified in the design documentation.

c) Periodic testing of overpressure protection devices (RV's) shall be performed as per CAN/CSA-N285.0. Overpressure protection devices (RV's) shall be removable for testing and/or maintenance without breeching the containment boundary.

d) Critical parameters of the SF transfer process system shall be verified by testing during the design phase.

e) Equipment shall be designed to permit the connection or insertion of any short-term instrumentation required for testing, site commissioning and maintenance.

f) Provision shall be made for the functional testing of the SF transfer and storage system during commissioning.

9. RELIABILITY AND MAINTAINABILITY

9.1 Reliability Requirements

a) The reliability of the SF transfer and storage system shall be assessed to demonstrate that no single failure of any portion of the system will:
   1) Compromise its and any interfacing system's safety related function,
   2) Prevent meeting the lifetime target capacity factor for the plant, specified in Appendix A.

b) The containment portion of the SF transfer and storage system shall be analysed to show that its contribution to the unavailability of the overall containment system does not raise the maximum demand unavailability of the overall containment system above the value specified in Appendix A.

c) The designer shall specify the replacement schedule for components that are predicated to fail before the design life, to ensure the failure rates specified in Appendix A is not exceeded.

d) The SF storage bays and any equipment required for the transfer of SF to dry storage, shall remain available for the time period specified in Appendix A.

9.2 Maintainability Requirement

a) The SF port and port valves (containment valves), which are inside the FM maintenance lock, shall be accessible for routine maintenance with the reactor at full power, subject to temporary constraints of contamination or operation.

b) The frequency of routine maintenance shall be compatible with station dose targets. The targets for maintenance unavailability and for frequency of routine maintenance are identified in Appendix A.

c) Maintenance of components or assemblies that are submerged under the bay water, such as the SF transfer mechanism, and SF storage container loading mechanism, shall have service intervals that correspond to station planned shutdowns. The target for planned service interval is as identified in Appendix A.

d) Components and assemblies (SF port and port valves) located inside the RB, having maintenance intervals that are less than a year, must be designed so that work can be completed within the time specified in Appendix A.

e) The design life of the major components of the SF transfer and storage system that cannot be replaced within one of the schedule outages shall be as specified in Appendix A, and subject to routine maintenance overhauls.

f) The design life of minor components that can be replaced during FH outages shall be as specified in Appendix A and subject to routine maintenance.

g) Where practical, components and manufactured parts shall be designed to be interchangeable. Commercially available components shall be used as much as possible.

h) The SF port end fitting and SF port valves (containment isolation valves) shall be easily replaceable.

i) It shall be possible to inspect the inside surface of the SF transfer tube, and replace it if necessary.

j) The design shall allow maintenance to be carried out without impairing the containment envelope.

k) Equipment design shall minimize the time required to maintain, repair or replace those parts/components subject to normal wear.

l) All underwater equipment, such as the SF transfer mechanism and SF container loading mechanism shall be removable for servicing without draining the water from the SF storage bay. This equipment shall be designed to be easily removable using remote tooling operated from over or beside the SF reception bays.

m) Components of the SF transfer and storage system shall be designed for easy purging of water contained in them.

n) The SF transfer and storage system design shall incorporate lifting arrangements to facilitate maintenance of the components and their transfer to the decontamination facility, whenever required.

o) As far as practical, equipment shall be located in areas of low background radiation fields, to limit maintenance related man-rem exposure.

p) Tools and calibration fixtures that are not commercially available, and are necessary for the maintenance of the SF transfer and storage system, shall be provided.

9.3 Unavailability

a) The unavailability of the SF transfer and storage system shall not prevent the station from achieving its availability targets. The SF transfer and storage system unavailability contribution shall be as specified in Appendix A. The number of days that the unit can operate at full power without refuelling is identified in Appendix A.

b) Where required, the design shall incorporate redundancy and/or accident recovery provisions to improve reliability and the availability of the SF transfer and storage system.

10. LAYOUT, MODULARIZATION AND STANDARDIZATION

a) The SF transfer and storage equipment shall minimize site construction and assembly where practical.

b) The design of the SF transfer and storage system shall employ standardized components and parts where practical. If non-standard components must be used, the number of different types and sizes shall be minimized.

c) Heat treatment, protective coatings and materials shall be standardized where possible.

d) The modular approach shall be adopted wherever practical, for all mechanical, fluid and electrical hardware (Reference 11).

e) Components that are required on each SF transfer system (two systems per unit) shall be fully interchangeable.

f) The location of the SF port containment valves shall accommodate the limited stroke of the FM ram, to ensure that a pair of SF bundles can be pushed past at least one of the port valves, and into the SF transfer process flow path, to ensure for bundle movement by hydraulic drag.

g) The SF port shall be accessible to the FM when it is supported from the maintenance rails.

h) The footprint of the SF transfer equipment in the RAB and in the SF storage bay shall be minimized.

i) The SF receiving equipment such as the SF transfer mechanism and fuel bundle handling equipment shall be submerged in the SF reception bays at a depth that provides sufficient water shielding, but is shallow enough to permit maintenance of equipment using manual tools from above or beside the SF reception bays.

j) Components of the SF transfer process system shall be provided on skids located in the RAB. The skids shall be supported from the floor. The location of the skids shall be in proximity to both SF transfer tubes and the SF storage bay.

k) The SF transfer tubes and SF transfer process piping, which passes through the containment wall, shall accommodate a relative vertical shift between the RAB and the RB due to differential settlement, and relative vertical and horizontal shifts due to displacement from an earthquake (DBE). The relative shifts are identified in Appendix A.

l) The SF transfer tube shall be supported by an embedment, in the reactor-building wall at one end and in the SF reception bay wall on the other end, in addition to intermediate supports.

m) The SF transfer and storage equipment (particularly SF transfer process equipment skids in the RAB, and the SF ports and SF transfer process pipes inside the FM maintenance lock) shall not inhibit inspection and maintenance of other equipment.

n) The design of the stacking frames shall take into consideration the layout of the SF storage bay, and the layout of the SF storage bay cooling and purification piping in the bay.

o) The facilities, some of which may be installed at a later date in the SF storage bay to accommodate dry fuel storage or other methods of fuel removal from the SF storage bay (refer to Section 2.2.1-ff), shall be located away from the SF reception bays, to limit the spread of contamination in the SF storage bay.

11. INTERFACING SYSTEMS

The systems identified in this section interface with the SF transfer and storage system. The interfacing requirements shall be described in more detail in the design requirement document for the respective system.

11.1 Requirements that the SF Transfer and Storage System Imposes on Interfacing Systems

11.1.1 Reactor Building (ASI 21000)

a) The RB shall have penetrations for the two SF transfer tubes, and the SF transfer process pipes.
b) The RB shall have embedments for the supports of the two SF transfer tubes, two SF ports, four SF port valves (two per SF port), and for the SF transfer process pipes.
c) Space shall be reserved inside the FM maintenance lock in the RB for the installation and maintenance of the SF ports, SF port valves with the connected auxiliaries and a portion of the SF transfer process piping.
d) The necessary space and embedments to mount IAEA safeguards cameras, video cameras, and radiation detection equipment shall be provided.
e) Sufficient biological shielding shall be provided in the FM maintenance lock to limit radiation fields to acceptable limits as specified in the safety requirement Section of Appendix A.
f) Access for FH maintenance personnel shall be provided to the SF transfer components in the RB, while the reactor is at power and SF is not in the FM or in the SF port. Access to the FM maintenance locks shall be controlled.
g) Means shall be provided in the FM maintenance locks for emergency egress of personnel.

11.1.2 Reactor Auxiliary Building (ASI 24000)

a) Provide necessary space and embedments in the RAB for the installation and maintenance of the SF transfer process system equipment.
b) Provide necessary space for the two SF transfer tubes.
c) Provide facilities for lifting and replacing the SF transfer process system equipment from the RAB and SF transfer equipment from the SF reception bays.
d) Provide access for FH maintenance personnel to the area where the SF transfer process equipment is located in the RAB.
e) Space and embedments shall be provided to mount IAEA safeguards equipment for fuel bundle counting, detection, and remote viewing.
f) Sufficient biological shielding shall be provided for the two SF transfer tubes and SF transfer process system to limit radiation fields to acceptable limits as specified in the safety requirement Section A.4 of Appendix A.
g) Safeguards access control shall be provided to the sections of the two SF transfer tubes that run between the RB and the SF reception bays in the RAB.

h) The RAB shall accommodate two water filled SF reception bays, a main SF storage bay, and an area for flasking.

i) The SF bays shall accommodate the following:

1) All the bays shall incorporate a stainless steel liner to minimize leakage.
2) The SF storage bay structure and liner shall be designed to support the SF storage container stacking frames, and shall withstand the effects of a fuel handling accident in combination with any practical arrangement or stored fuel.
3) The SF reception and storage bays shall have a sufficient depth, so that the minimum water shielding over the SF storage containers and over the components of the SF transfer system shall be maintained. The minimum water shielding to be maintained is specified in the performance requirements Section A.3 of Appendix A.
4) One SF transfer mechanism and one SF storage container loading mechanism for each SF port, with necessary supports.
5) Sufficient storage containers and stacking frames for the estimated quantity of SF produced during the period specified in Section A.3 of Appendix A. The estimated quantity of SF bundle is also identified in Section A.3 of Appendix A.
6) The storage containers for SF freshly removed from the core, until they are sufficiently cool for storage in the stacking frames.
7) SF bay tools.
8) Space shall be provided in the SF storage bay, to carry out the activities associated with the transfer of SF to dry storage.
9) The SF reception bays shall be separated from the SF storage bay, in order to control the spread of contamination between these areas.

j) The SF bay room shall have provisions for the following:

1) Embedments in the SF storage bay room for the installation and maintenance of the crane and manbridge that span the bay.
2) The SF storage bay room shall include an area around the bay at the operations level for SF transfer equipment, and for FH operators and maintainers to access the SF transfer equipment. A laydown area shall be provided for equipment that is being installed or removed from the bay.
3) Access routes into the SF storage bay room shall be sized for personnel and the largest SF transfer assemblies. A means shall be provided for controlling the access.
4) The SF bay room shall include facilities to minimise airborne contamination from normally submerged SF transfer equipment that is removed from the bay water.
5) Space shall be provided to accommodate dry fuel storage or other methods of fuel removal from the SF storage bay. Space shall also be provided for access to these facilities.

11.1.3 Fissionable Materials Safeguards (ASI 30100)

The design of the SF transfer and storage system shall be suitable for incorporation of IAEA Safeguard Standards by taking into consideration the positioning of mounting brackets for monitoring equipment.

11.1.4 Heat Transport Purification System (33350)

a) The HT purification system shall accommodate some demineralised water transferred from the SF transfer process system to the FM water system via the FM snouts during SF and hardware transfer from the FMs to the SF reception bays. Under normal operating conditions, direct transfer of water from the SF reception bays to the HT system via the FMs shall be avoided. Any transfer of mixtures containing bay water shall be minimized. The load and duty cycle are specified in Appendix A.

b) The HT purification system shall accommodate a mixture of FM water (HT chemistry water) and SF transfer process water (demineralised water) following hardware transfers from the SF reception bays to the FMs. This mixture is directed to the HT purification system via the FM water system. Under normal operating conditions, direct transfer of water from the SF reception bays to the HT system via the FM shall be avoided. Any transfer of mixtures containing bay water shall be minimized. The load and duty cycle are specified in Appendix A.

c) The HT purification system shall accommodate a mixture of FM water (HT chemistry water) and SF transfer process water (demineralised water) following SF transfers back to the FM. This mixture is directed to the HT purification system via the FM water system. The load and duty cycle are specified in Appendix A.

11.1.5 SF Storage Bay Cooling and Purification System (ASI 34410)

a) The SF storage bay cooling and purification system shall remove decay heat generated by the SF in the bay. The decay heat load to be removed is specified in Appendix A.

b) The SF storage bay cooling and purification system shall maintain the clarity of the bay water to facilitate visual inspection of the SF bundles, and the maintenance of submerged equipment using remote manual tooling.

c) The SF storage bay purification system shall accommodate demineralised water injected into the SF reception bays from the SF transfer magazines during fuel transfers. There may be trace amounts of P & IC water. The load and duty cycle are specified in Appendix A.

d) The SF storage bay purification system shall remove suspended and soluble radioactive materials from the bay water to minimise airborne contamination from normally submerged SF transfer equipment that is removed from the bay water.

e) The design and layout of the SF storage bay cooling and purification system shall be such that breakage or shutdown of the system does not lead to the draining of the SF bays.

f) The design and layout of the SF storage bay cooling and purification system inside the bay shall not interfere with the layout of the SF transfer system components in the bay.

g) The SF storage bay cooling and purification system shall maintain the minimum water shielding over the SF storage containers and over the components of the SF transfer system submerged in the SF bays. The minimum water shielding to be maintained is specified in the performance requirements Section A.3 of Appendix A.

h) The SF storage bay cooling and purification system shall be designed to provide makeup at a rate at least sufficient to compensate for evaporative losses with the SF storage bay at the maximum design temperature.
i) The SF storage bay cooling and purification system shall be designed to minimize the transfer of contamination between the SF reception bays and the main fuel storage bay.
j) The water chemistry in the SF bays shall be controlled so as not to adversely affect the material properties of the cladding of the stored SF, the structural members of the SF bays, and the SF bay cooling and purification system.
k) The water chemistry/condition in the SF bays shall be controlled as necessary to keep stored SF sub-critical.

11.1.6 Fuel Changing Equipment (ASI 35200)

a) The FM shall clamp onto, and make a pressure tight seal with the SF port before opening the SF port valves (containment valves).
b) SF bundles shall be transferred from the FM magazine submerged in water, at a pressure that exceeds RB design pressure.
c) The FM ram stroke length shall be sufficient to transfer SF bundles past at least one of the port valves (containment isolation valves), and into the SF transfer process flow path (for bundle movement by hydraulic drag).
d) The FM magazine shall receive SF and hardware transferred under hydraulic drag through the SF transfer tube.
e) Provisions shall be included to minimize coolant losses when disengaging the FM from the SF port.

11.1.7 FM Water System (35230)

a) The FM water system shall accommodate some demineralised water from the SF transfer process system during SF and hardware transfers from the FMs to the SF reception bays, as identified in Section 11.1.4-a). This is discussed under the heading of the HT purification system because during SF transfer, the water in the FM returns to the HT purification system.
b) The FM water return sub-system shall accommodate water transferred from the SF transfer process system following SF and hardware transfers to the FM, as identified in Section 11.1.4-b) and c). This is discussed under the heading of the HT purification system because following the SF or hardware transfer, the water in the FM returns to the HT purification system.
c) The FM water system shall supply SF emergency cooling water to the appropriate location in the SF transfer system, upon loss of the SF transfer process system. The emergency cooling water requirements are specified in Appendix A.

11.1.8 Electrical Supply System (ASI 50000)

a) Seismically qualified, Class II power shall be provided for the following:
   1) The monitoring of SF transfer and storage system components that perform a safety function (for example: SF port valves and process valves which provide containment isolation; SF transfer magazine and SF transfer tube water temperature; emergency cooling flow).
   2) The control of SF transfer and storage system components that perform a safety function (for example: SF port valves and process valves which provide containment isolation; emergency cooling process valves).
   3) The operation and monitoring of safeguards equipment.

b) Class II power shall be provided for the control and monitoring of the balance of the SF transfer and storage system (FCS, FDS, instrumentation, etc.).

c) Seismically qualified, Class III power shall be provided for the operation of any pumps required for emergency SF cooling.

d) Class III power shall be provided for the operation of the balance of the SF transfer system (for example: the balance of the pumps and valves of the SF transfer process system; electric drives of the SF transfer mechanisms; etc.).

e) Refer to Section 15.1.4 for voltage and frequency considerations.

11.1.9 Lighting and Building Electrical Services (ASI 56000)

a) Lighting shall be provided in the SF storage bay area. The lighting shall be suitable for FH activities and remote safeguards monitoring. Power supplies to the SF storage bay lighting shall be independent from other lighting and meet the reliability requirements for safeguards equipment.

b) Seismically qualified, Class II power shall be provided for underwater lighting in the SF storage bay. The illumination must be sufficient to allow for close examination of the fuel bundles.

c) Lighting shall also be provided in the areas where in SF transfer process system equipment and the SF transfer tubes are located.

11.1.10 Communication (ASI 60200)

Communication jacks are required at each Breathing Air Station. A telephone shall be required in the SF storage bay and near the SF transfer process skid.

11.1.11 Radiation Monitoring (ASI 60800)

Fixed Area Gamma Monitors are required in accessible areas containing SF transfer and storage equipment, to alarm at radiation level exceeding 5 μSv/h.

11.1.12 Re-circulated Cooling Water System (ASI 71340)

During SF transfers, the re-circulated cooling water system shall supply cooling flow to the SF transfer process system cooler at a rate specified in Appendix A.

11.1.13 Fire Protection System (ASI 71400)

Suitable fire protection shall be provided for the SF storage bay area and also for the areas where in SF transfer process system skid and the SF transfer tubes are located.

11.1.14 Demineralised Water System (ASI TBD)

Demineralised water shall be supplied to the SF transfer process system to provide an interface between the FM water and the SF reception bay water.

a) The demineralised water system shall supply water to the SF transfer process system for the initial filling of the system. The capacity of the SF transfer system is specified in Appendix A.

b) The demineralised water system shall supply make-up water to the SF transfer process system. The make-up load and duty cycle are specified in Appendix A. The make-up water shall be available under normal conditions, during and following a LOCA or MSLB, and following a loss of Class IV power.

c) A flow of demineralised water from the SF transfer magazines into the SF reception bays shall be provided whenever the transfer mechanism magazines are open to the SF reception bays, to keep the internals of the SF transfer system free of crud and other contaminants from the SF reception bay. The load and duty cycle are specified in Appendix A.

d) Demineralised water shall be provided to the location in the SF storage bay area reserved to accommodate dry fuel storage or other methods of fuel removal from the SF storage bay, to facilitate washdown and decontamination of fuel canisters and flasks.

e) The demineralised water system shall supply water for the operation of hydraulically operated rams and tools in the SF storage bay, as specified in Appendix A.

11.1.15 RAB Active Drainage System (ASI 71740)

Drains shall be provided near the SF transfer process skids to accommodate leakage from the SF transfer process system.

11.1.16 Reactor Auxiliary Building Ventilation System (ASI 73400)

a) The areas where the SF transfer process system equipment and the SF transfer tubes are located, shall be provided with adequate ventilation to maintain the air borne contamination within acceptable limit in the event of a leak from the process system.

b) Provision shall be made for venting the SF transfer magazine to the ventilation system, while purging the magazine for maintenance activities.

c) Provision shall be made for the venting of fuel canisters and flasks at the location in the SF storage bay area reserved to accommodate dry fuel storage or other methods of fuel removal from the SF storage bay.

d) The SF storage bay area shall be maintained at a lower pressure than the adjacent areas of the RAB, to limit the spread of airborne contamination.

e) The RAB ventilation system shall have provisions for airborne radioactivity monitoring, such that gaseous effluents having the potential for carrying radioactivity are monitored with appropriate alarms to signal high activity levels.

11.1.17 Service Air System (ASI 75110)

Service air outlets shall be provided in the SF storage bay area and near the SF transfer process system skids, for powering maintenance tooling.

11.1.18 Instrument Air System (ASI 75120)

Instrument air stations shall be provided in the SF storage bay area, near the SF transfer process system skids and in the FM maintenance locks to operate various valves, cylinders and other components of the SF transfer and storage system. The supply lines shall be provided with hand operated shut-off valves.

11.1.19 Breathing Air System (ASI 75130)

Breathing air stations shall be provided in the FM maintenance locks, around the perimeter of the SF reception bays, and around the SF storage bay.

11.1.20 Cranes and Hoist (ASI 76030)

a) Lifting equipment shall be provided in the RAB for handling SF transfer process system components.
b) Lifting equipment shall be provided over the reception bays for handling SF transfer mechanism components.

11.1.21 Decontamination (ASI 78510)

Waste management facility shall be able to handle contamination from the SF transfer and storage system components as and when required.

11.1.22 Off Gas Management System (ASI 79300)

a) The SF transfer magazine vents shall be connected to the off gas management system. Venting of the SF transfer magazine shall be required intermittently while transferring defective SF to the SF reception bay, to draw off residual contaminated vapour and active gases. The defective fuel bundle handling rate is identified in the performance requirements Section A.3 of Appendix A.
b) An active gas collection hood located in each SF reception bay shall be connected to the off gas management system. Active gas collection will be required following the transfer of defective fuel to the SF reception bay. The defective fuel bundle handling rate is identified in the performance requirements Section A.3 of Appendix A.

12. DECONTAMINATION AND DECOMMISSIONING

a) The design of the SF transfer and storage system components, shall allow for easy cleanup to remove fuel debris and other active contaminants trapped in it. Small crevices etc. shall be avoided.

b) The design of system components shall allow for easy decontamination of internal and external surfaces.

c) Materials and coatings shall be selected for easy decontamination where possible.

d) Materials shall be selected considering chemical decontamination.

13. MATERIALS AND CHEMISTRY

a) The SF transfer process system shall be filled with demineralised water, but may become contaminated with some FM water (HT chemistry) and trace amounts of SF bay water.

b) All materials in contact with HT chemistry water shall be corrosion resistant and compatible with HT chemistry water. They must be capable of withstanding the chemical, thermal and radiation environment to which they will be exposed.

c) All materials in contact with SF bay water shall be corrosion resistant and compatible with the chemistry of the SF bay water purification system. They must be capable of withstanding the chemical, thermal and radiation environment to which they will be exposed.

d) The SF port assemblies, port valves (containment isolation valves) and a portion of the SF transfer process piping, which are inside the containment will be subjected to the harsh environments associated with a DBA (MSLB inside containment, or LOCA). These components shall be qualified to perform their safety function during and following a DBA.

e) The use of the following elements and/or materials shall be eliminated in the design of components that are wetted by the HT chemistry water:

   1) Aluminium - to avoid chemical interaction with other system materials, and chemical attack by the lithium in the HT system coolant.
   2) Lead - to avoid cracking of high nickel alloys.
   3) Copper - to avoid corrosion products in the HT system.
   4) Halogens (chlorine, fluorine, etc).

f) The use of the following elements and/or materials shall be minimized in the design of components that are wetted by the HT chemistry water:

   1) Cobalt - to avoid formation of long life isotopes.
   2) Lubricants that may create problems with decomposition products.

g) The absorption of oxygen, nitrogen and carbon dioxide by the HT chemistry water from the ambient atmosphere resulting from fuel changing operations shall be minimised.

h) The pH of coolants is identified in Appendix A.

i) Materials that do not normally contact water shall be made from corrosion resistant material or protected by corrosion resistant surface treatments wherever practical.

j) Liquid level detection equipment in process tanks and the mechanism magazines shall not be impaired by changes in the pH of the water.

k) The surface materials on which fuel bundles slide (for example, the SF transfer tubes and SF transfer magazine tubes), shall be selected to minimize the wear of the fuel bundle pads and the material.

l) The SF transfer and storage system equipment shall not contaminate SF and hardware that may be transferred to the FM. This includes all lubricants and surface coatings etc. that the fuel bundles will contact during transfer and storage.

m) Materials of submerged equipment shall be suitable for any chemical treatments they might be subjected to (e.g. passivation of the stainless steel liners prior to the filling of the bay).

14. LOADS, LOAD COMBINATIONS AND SERVICE LIMITS

The loading conditions are classified as design, service or test conditions. The service conditions are further classified as normal (level A), upset (level B), emergency (level C) and faulted (level D) in accordance with the ASME Boiler and Pressure Vessel Code Section III.

The fuel handling system must meet the service requirements listed below:

a) Design specifications shall be prepared for the Class 2, 3, 4 and 6 piping systems, pressure retaining components, and components supports in accordance with CAN/CSA-N285.0 and CSA B51.
b) The SF port shall accommodate the FM misalignment and seismic forces.
c) The SF port, port valves, SF transfer tubes and SF transfer process piping shall accommodate the load induced due to pressures and temperatures imposed by the FM head and the SF transfer process system.
d) The SF ports, port valves (containment isolation valves), and a portion of the SF transfer tube and SF transfer process system, which are inside the containment will be subjected to the harsh environment of a DBA (MSLB and LOCA). This equipment shall accommodate the loads induced by these accident conditions.
e) The SF ports, port valves (containment isolation valves), SF transfer tubes and a portion of the SF transfer process system up to isolation valves shall be qualified to DBE.
f) The level C service limits shall include LOCA, MSLB and DBE conditions which shall not cause failures of the SF ports, port valves (containment isolation valves), SF transfer tubes or SF transfer process piping up to the isolation valves, to avoid steam release into the RAB. It shall also consider fuel cooling by emergency water supply in case of a normal water supply failure.
g) The SF transfer mechanism shall not apply sufficient axial load to overstress the SF bundles.
h) Level A,B,C and D conditions are described below.

Table 14-1
Service Conditions

Condition	Description	Requirement
Level A	Normal operating	Full functionality
Level B	Upset	Full functionality
Level C	Emergency	Safety functions must operate, with the possibility of service work required afterwards
Level D	Faulted	Failure must not interfere with safe shutdown

15. HUMAN FACTORS AND OTHER DESIGN REQUIREMENTS AND CONSTRAINTS

15.1 Design Constraints

15.1.1 General Design Constraints

a) The design shall accommodate the objectives of the ACR-700 project including lower capital cost, shorter construction and commissioning schedules, lower operating and maintenance costs, low man-rem consumption, and enhanced safety.

b) The delivery schedule for the SF transfer and storage system equipment shall be compatible with the schedule for the construction sequence. Commissioning work at site shall be minimized.

c) Design decisions must consider the impact to the overall cost of the station.

d) The SF transfer and storage system controls and indicators mounted on panels and consoles in the MCR shall match others in the MCR, where practical.

e) In general, the appearance and finish of the SF transfer and storage system panels and consoles in the MCR shall conform to other panels in the MCR.

f) The RB and RAB layout affects the orientation of the SF port in the containment wall, such that the SF port may be at an angle to the FM carriage tracks in the maintenance lock.

g) The SF transfer and storage system shall not use oil hydraulic actuators or drives.

h) The limited stroke of the FM ram shall be considered when locating the SF port containment isolation valves.

15.1.2 Constraints Imposed by Heat Transport Purification (33350)

The temperature and pressure of water sent to the HT purification system from the SF transfer process system via the FM water system shall be as specified in Appendix A.

15.1.3 Constraints Imposed by Fuel Bundles (37000)

a) Care shall be exercised to avoid damage to fuel including:
   1) Impact loads must be within acceptable limits. Impact loads at cold temperatures must be minimized, particularly loads that are not applied squarely to the bundle ends.
   2) Axial (compression and tension) and radial loads must be within acceptable limits identified in Appendix A (Reference 1).
   3) No torque shall be applied to the fuel at any time during fuel handling.

b) Contact of the fuel bundle should only be via the bearing pads, endcaps and/or endplates. No sheath contact should be permitted, with the exception that contact is permitted for the purpose of sensing fuel bundle location. Normal contact forces on the fuel sheath during fuel sensing and inspections must not damage the fuel sheath.

c) The diameter of any passage through which the fuel bundle passes shall be larger than the uncrept pressure tube inside diameter identified in Appendix A.

d) The condition of any passage through which fuel bundle passes (including bends, misalignments, and steps in the passage) shall be such that a force required to push a fuel bundle shall be less than that specified in Appendix A.

e) The maximum vertical step height in any component, or misalignment of any two components, that forms a part of the passage through which fuel passes shall not interfere with normal bearing pad passage. The permissible maximum vertical step height or misalignment is identified in Appendix A.

f) The fuel bundle shall be radially supported at all times during transfer to the SF reception bays. Axial gaps in support surfaces over which fuel must travel shall not interfere with the normal passage of the bearing pads. The maximum axial length of "gaps" over which fuel is permitted to travel is identified in Appendix A.

g) The inter-element spacers of the fuel bundle shall not get interlocked during normal handling and operation.

h) During fuel transfer under hydraulic drag, the loads and vibration caused by the flow shall be less than those caused by the cross-flow in the outlet liner hole region of the end fittings.

15.1.4 Constraints Imposed by Electrical Supply System (ASI 50000)

a) The design of electrical portion of the system and the selection of electrical equipment shall be based on the supply voltages specified in Appendix A.

b) The design shall also facilitate a change to the alternate supply voltages specified in Appendix A.

15.1.5 Constraints Imposed by Failed Fuel Detection System

Space shall be provided in the SF transfer system for failed fuel detection equipment.

15.2 Human Factor Requirements

a) In accordance with the CNSC policy on Human Factors P-119 (reference Section 5.1), the SF transfer and storage system design shall take into consideration known Human Factors related issues from the operations and maintenance feedback of existing CANDU power plants. A Human Factors assessment of the detailed design shall be conducted, and where non-conformances with the Human Factors requirements are identified, the system design shall be amended in order that Human Factors requirements are satisfied.

b) Human Factors (permissible weights, arm reach, physical access etc.) shall be in accordance with the Human Factors Engineering Program Plan (Reference 16).

16. REFERENCES

[1] 108-35000-DR-001 Fuel Handling and Storage System Design Requirements.

[2] 108-63581-DR-001 Fuel Handling Control System Design Requirements.

[3] 108–03650–SDG–001 Safety Related Systems Safety Design Guide.

[4] 108–03650–SDG–002 Seismic Requirements Safety Design Guide.

[5] 108–03650–SDG–003 Environmental Qualification Safety Design Guide.

[6] 108-03650-SDG-004 Separation of Systems and Components Safety Design Guide.

[7] 108–03650–SDG–005 Fire Protection Safety Design Guide.

[8] 108–03650–SDG–006 Containment Safety Design Guide.

[9] 108–03650–SDG–007 Radiation Protection Safety Design Guide.

[10] 108-01913-QAM-001 ACR QA Manual.

[11] 108-01720-DG-001 General Guidelines for Layout of Modules.

[12] 108-37000-DR-001 ACR Fuel Bundle.

[13] 10810-33350-DR-001 Heat Transport Purification System.

[14] 10810-01372-TED-001 ACR-700 Technical Outline.

[15] 108-30100-DG-001 Safeguards Concept and Design Guide.

[16] 108-03800-PPS-001 Human Factor Engineering Program Plan.

Appendix A

Numerical Data

Note: 1) All data not accompanied by a Reference shall be considered as preliminary.

A.1 Introduction (Section 1)

No numerical data

A.2 Functional Requirements (Section 2)

Number of fuel channels	284 (Reference 14)
FM water transfer to SF bays (maximum)/day, includes leakage across valves plus volume transferred during SF and hardware transfers (Refer to Section 11.1.5 of Appendix A.11)	<1.5 L/day (preliminary)
Alarm at water temperature (in SF transfer tube or SF magazine)	66°C (preliminary)
Temperature for automatic initiation of emergency cooling water supply	100°C (preliminary)
Low pressure (in SF transfer tube) alarm	0.8 kPa below atmospheric (preliminary)

A.3 Performance Requirements (Section 3)

3.1 Normal Operation:

Number of fuel bundles replaced per refuelling cycle:	2
Note: The fuelling rate for the initial fuel load may be significantly higher than the equilibrium fuelling rate identified below.	
Equilibrium fuelling rate (channels / week):	19.6
• Equilibrium fuelling rate (channels / day), if fuelling 7 days / week:	2.8 (Reference 1)
• Equilibrium fuelling rate (channels / day), if fuelling 4 days / week:	4.9
Pairs of SF bundles to bay / SF port / week (bi-directional fuelling):	9.8
• SF transfer cycles / SF port / week, for 3 SF bundle pairs per cycle:	~ 4
• SF transfer cycles / SF port / week, for 6 SF bundle pairs per cycle:	~ 2
Advanced or catch-up SF transfer rate (channels / day):	5 - 6 (preliminary)
Pairs of SF bundles to bay / SF port / day (bi-directional fuelling):	2.5 – 3.0
• SF transfer cycles / SF port / day, for 3 or 6 SF bundle pairs per cycle:	1
SF storage capacity	10 + 1 year of station operation at 93% capacity factor, + 1 full core load (preliminary)
Number of channels to be defuelled for pressure tube inspection	10 (preliminary)
Time to transfer fuel to the bay for channel inspection	2 days (preliminary)
SF transfer mechanism capacity	12 fuel bundles
Capacity (minimum) of SF storage bay	26640 bundles
Capacity (minimum) of buffer zone	1560 bundles (preliminary)
Storage period in buffer zone (minimum)	5 days (preliminary)
Cooling water flow (minimum) to cool 6 pairs of SF bundles in the SF transfer mechanism	1.6 L/sec (preliminary)

Minimum water flow to move a pair of fuel bundle, or a fuel grapple tool with fuel bundle attached, or a fuel grapple extension, or a shield plug	25 L/sec. (preliminary)
Decay heat load (maximum) in each SF transfer tube from a pair of SF bundles	18.8 kW (preliminary)
Decay heat load, considering heat load (maximum) in one SF transfer tube and one SF transfer magazine (total 6 pairs of SF bundles)	112.8 kW (preliminary)
Permissible leakage past the containment valve	[TBD]
Defective fuel bundle handling rate	0.1% of fuel throughput (preliminary) (Reference 1)

3.2 Abnormal Operation:

Time period (maximum) for core de-fuelling	15 days (preliminary)
Maximum trips of FM to each SF port/day	13 (preliminary)

3.3 Safety related:

Safe temperature for SF bundles	[TBD]
Minimum water over SF storage containers in stacking frames	4.3 meter (preliminary)

A.4 Safety Requirements (Section 4)

Station man-rem	[TBD]
FH System man-rem consumption	[TBD]
Peak Horizontal Ground Acceleration	0.30 g (Reference 4)
Maximum time allowed for fuel bundle to be in air (SF is required to be submerged at all times for normal operations)	4 minutes (preliminary)
Time period available for action by operator in MCR after clear and unambiguous indication	15 minutes (preliminary)
Maximum permissible radiation dose with radiation shielding:	
General Access Area	5 μSv/h (preliminary)
Controlled Access Area	250 μSv/h (Preliminary)
Emergency Access	1000 μSv/h (Preliminary)

A.5 System/Component Classification (Section 5.3)

The basket and stacking frame size shall facilitate sealing every SF bundle in a full stacking frame within 3 months of transfer to the bay under normal operating conditions (Reference 15).

A.6 Environmental Conditions (Section 6)

Radiation around the SF port with the FM clamped on	[TBD]
Normal Operating Conditions within the RB (Reference 1):	
Temperature	18°C - 40°C
Relative Humidity	up to 90%
Pressure	0.7 kPa below atmospheric
Abnormal Operating Conditions within the RB:	
LOCA	see Reference 6
MSLB	see Reference 6
Operating conditions within RAB (Reference 1):	
Temperature	18°C - 40°C
Relative Humidity	50% - 60%
Integrated yearly radiation dose	[TBD]
Pressure	atmospheric
Operating conditions in the SF storage bay room (Reference 1):	
Temperature	[TBD]
Relative Humidity	[TBD]
Integrated yearly radiation dose	[TBD]
Pressure	[TBD]

A.7 Over Pressure Protection Requirements (Section 7)

No numerical data.

A.8 Inspection and Testing Requirements (Section 8)

No numerical data.

A.9 Reliability and Maintainability Requirements (Section 9)

Reliability:	
Plant design life	60 years (Reference 14)
Life of SF storage bay and equipment required for the transfer of SF to dry storage	71 years (preliminary)
Lifetime target capacity factor	> 90% (Reference 14)
Maximum demand unavailability of the overall containment system	10^{-3} years/year (preliminary)
Target failure rate for SF transfer and storage equipment	$<10^{-5}$ years/year (preliminary).
Maintainability requirements:	
Target for frequency of routine maintenance and maintenance unavailability	Once per week or less with maintenance time less than 20 hours per week (preliminary)
Target for planned service interval	24 months or greater (preliminary)
Target for maintenance time of components located inside RB, having maintenance interval less than a year	3 hours (preliminary)
Design life of major components that cannot be replaced within one of the scheduled outages	60 years (preliminary)
Design life of minor components that can be replaced during FH outages	5 years (preliminary)
Unavailability:	
FH System unavailability contribution	≤ 10% (preliminary) (Reference 1)
Number of full power days available with no refuelling	7 (preliminary)

A.10 Layout, Modularisation (Section 10)

Relative shift between RB and RAB:

Due to differential settlement:	Vertical:	25 mm (preliminary)
Due to an earthquake:	Vertical:	25 mm (preliminary)
	Horizontal:	50 mm (preliminary)

A.11 Interfacing Requirements (Section 11)

Refer to A.3, Appendix A for performance requirements.

Note: The fuelling rate for the initial fuel load may be significantly higher than the equilibrium fuelling rate. The fluid volumes identified in Section 11 for equilibrium fuelling are to be adjusted for fuelling of the initial fuel load.

11.1.4 Heat Transport Purification System (33350)

11.1.4 a) SF and Hardware Transfers from the FMs to the SF Bays

The volume of demineralised water transferred to HT purification via FM snout is dependent on the amount of mixing of FM water and SF transfer water that takes place as fuel bundles and hardware are pushed out of the FM, and as the ram is retracted back into the FM.

- Temperature of water at point of transfer to HT purification: ≤ 66°C (Reference 13)

For equilibrium fuelling (Refer to Appendix A.3):

- Volume of demineralised water transferred via FM snout, per week (maximum): Demineralised 120 L (prelim.)

For advanced or catch-up fuelling (Refer to Appendix A.3):

- Volume of demineralised water transferred via FM snout, per day (maximum): Demineralised 50 L (prelim.)

For SF transfers to the SF bays prior to channel inspection:

• Volume of demineralised water transferred via FM snout, per day, over a period of 2 days:	Demineralised 125 L (prelim.)	

11.1.4 b) and c) SF or Hardware Transfers from the SF Bays to the FMs (Limiting Requirements)

• Volume of demineralised water transferred via FM snout, to FM water system per cycle, assuming the transfer of one pair of fuel bundles, or one piece of hardware:	Demineralised 500 L (prelim.)	

11.1.5 SF Storage Bay Cooling and Purification System (ASI 34410)

11.1.5 a) SF Bays Heat Load

Decay heat load in the SF bays	[TBD]

11.1.5 c) Water Transferred to SF Bays from SF Transfer Magazines

• Temperature of water at point of transfer to SF bay purification:	≤ 66°C (preliminary)
• Flow rate (maximum):	2 L/s (preliminary)

For equilibrium fuelling (Refer to Appendix A.3):

• Volume of (demineralised + HT chemistry) water transferred from SF transfer magazines, per week (maximum):	Demineralised 2000 L (prelim.)	+	HT Chemistry 1.2 L (prelim.)

For advanced or catch-up fuelling (Refer to Appendix A.3):

• Volume of (demineralised + HT chemistry) water transferred from SF transfer magazines, per day (maximum):	Demineralised 1000 L (prelim.)	+	HT Chemistry 500 mL (prelim.)

For SF transfers to the SF bays prior to channel inspection:
(Limiting Requirements)

	Demineralised		HT Chemistry
• Volume of (demineralised + HT chemistry) water transferred from SF transfer magazines, per day, over a period of 2 days	2500 L (prelim.)	+	1.3 L (prelim.)

11.1.7 FM Water System (35230)

11.1.7 c) Emergency Water Supply to SF Transfer System

Emergency cooling water requirement considering maximum heat load in one SF transfer tube and one SF transfer magazine — 1 L/sec. (preliminary)

11.1.12 Re-circulated Cooling Water Requirements

Re-circulated cooling water flow — 30 L/sec. (preliminary)

11.1.14 Demineralised Water System (ASI TBD)

11.1.14 a) Initial Filling Requirements

- Capacity of SF transfer system (including 2 SF transfer tubes; excluding reservoir): 2500 L (preliminary)
- Capacity of SF transfer reservoir tank: 4000 L (preliminary)

11.1.14 b) Make-Up Requirements: 100 L/day (preliminary)

11.1.14 c) Fuel Transfer Flow & Volume Requirements:

- Flow Rate (maximum): 2 L/s (preliminary)

For equilibrium fuelling (Refer to Appendix A.3):

- Volume of water per week (maximum): 2000 L (preliminary)

For advanced or catch-up fuelling (Refer to Appendix A.3):

- Volume of water per day (maximum): 1000 L (preliminary)

For SF transfers to the SF bays prior to channel inspection:
(Limiting Requirements)

• Volume of water per day over 2 days:	2500 L (preliminary)
11.1.14 e) Water Flow For Operation Of Rams And Tools:	[TBD]

A.12 Decontamination and Decommissioning Requirements (Section 12)

No numerical data.

A.13 Materials and Chemistry Requirements (Section 13)

HT system coolant	9.8 –10 (Reference 1)
SF transfer process system coolant	[TBD]
SF reception and storage bay water	[TBD]

A.14 Load, Load Combinations and Service Limits (Section 14)

To be provided.

A.15 Human Factors, Other Design Requirements and Constraints (Section 15)

15.1.2 Constraints Imposed by Heat Transport Purification (33350) (Reference 13)

Maximum temperature of water to HT purification	66 ºC (preliminary) (Reference 13)
Maximum pressure of water to HT purification	1.3 MPa (preliminary) (Reference 13)

15.1.3 Constraints Imposed by Fuel Bundles (37000) (Reference 1)

Maximum allowable radial load on fuel sheath	[TBD]
Maximum compressive force, applied uniformly to end plates	[TBD]
Maximum tensile force, applied uniformly to end plates	[TBD]
Maximum axial compressive force applied to fuel pencils	[TBD]

Uncrept pressure tube inside diameter	103.38 (+0.84/-0.0) mm (Reference 12)
Maximum fuel bundle pushing force	200 N (Reference 1)
Allowable radial misalignment between two adjacent fuel passage ways	0.5 mm (Reference 1)
Maximum length of gap allowable in fuel passage ways	45 mm (Reference 1)
Variation in the length of fuel bundles	[TBD]

15.1.4 Constraints Imposed by Electrical Supply System (ASI 50000)

Electrical Design Parameters: (Reference 1)

Design supply voltages	
Canada:	575/600 VAC and 208 VAC, 3 phase, 60 Hz
USA:	460/480 VAC, and 208 VAC, 3 phase, 60 H
UK:	400/415 VAC, 3 phase, 50 Hz
Alternate supply voltages	
Canada:	120 and 240 VAC, 1 phase, 60 Hz
USA:	120 and 240 VAC, 1 phase, 60 Hz
UK:	240 VAC, 1 phase, 50 Hz